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(54) Title: HYDROCARBON FUEL PROCESSOR CATALYST

(57) Abstract: A catalyst for use in a hydrocarbon fuel processor for converting, or reforming, a hydrocarbon fuel such as diesel into a simple fuel, most especially hydrogen, comprises a rare earth metal (M) cobalt oxide (Mco_3O_4) having the perovskite structure. In one composition the catalyst comprises a solid solution having the perovskite structure of the rare earth metal cobalt oxide, preferably lanthanum cobalt oxide $LaCoO_3$, and an alkaline earth metal cobalt oxide, preferably strontium cobalt oxide $SrCoO_3$. To further enhance the catalytic activity the catalyst can additionally include a noble metal oxide such as platinum or ruthenium.

HYDROCARBON FUEL PROCESSOR CATALYST

This invention relates to a hydrocarbon fuel processor catalyst for converting or reforming a hydrocarbon fuel into a simple fuel and is more especially, although not exclusively, concerned with a catalyst for converting a liquid hydrocarbon fuel to hydrogen for use in a fuel cell.

Fuel cells offer the promise of smaller and lighter weight power sources that are potentially instantaneous and silent in their operation. For example, fuel-cell powered vehicles are currently being developed as a more fuel-efficient and less polluting alternative to the internal combustion engine.

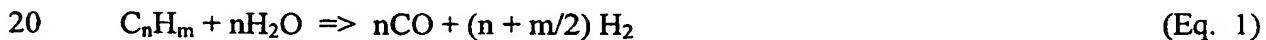
For large scale, generally static applications, solid oxide fuel cells can be used. Due to their high operating temperature, typically around 800°C, such fuel cells are able to directly utilise fuels such as methanol, methane or natural gas. Whilst suitable for large scale operation, such as combined heat and power facilities for building complexes, these cells are not suited to mobile applications as they are bulky and have a slow start up due to their high operating temperature.

For mobile applications such as vehicles, polymer fuel cells have been proposed. Due to their relatively low operating temperature (typically around 80°C), such cells offer a rapid start up as required in these applications. Polymer fuel cells operate most efficiently on pure hydrogen, but it is currently difficult to store hydrogen on board the vehicle in a safe and cost effective way. A fuel processor or reformer converts

hydrocarbon fuels to hydrogen gas, potentially enabling fuel-cell powered vehicles to run on fuels which are widely available today, such as liquefied petroleum gas (LPG), paraffin, gasoline or diesel.

5 Compact fuel processors suitable for use on vehicles have already been developed for
lighter hydrocarbon fuels such as methanol. However, these processors are usually
specific to one type of fuel and require a high purity feed since impurities such as
sulphur are very detrimental to the reforming catalyst and can permanently deactivate
it. It is therefore desirable to produce a compact fuel processor that can extract
10 acceptable amounts of hydrogen from a wide range of commercial fuels and function
without adjustment as the fuel type changes. These new reforming catalysts should be
much more resistant to coking or sulphur deactivation than the currently available
catalysts.

15 A number of different designs of fuel processor have been proposed for converting hydrocarbon fuels to hydrogen which are based on a steam-reforming reaction in which vaporised hydrocarbon fuel is reacted with steam (H_2O). This reaction can be represented by the following endothermic equation:



A catalyst may optionally be used to increase the reaction rate, though high temperatures and pressures are still required. As can be seen from the equation, the carbon in the hydrocarbon fuel is converted to carbon monoxide by oxidation using

the oxygen provided by the steam whilst the hydrogen in the fuel and steam is released as hydrogen gas. The optimum steam to carbon ratio ($H_2O:C$) depends on the processor conditions (temperature and pressure), but invariably this ratio increases as the carbon content of the hydrocarbon increases. Large quantities of steam are therefore required for heavy fuels such as diesel and this demands a high energy input to vaporise the water, leading to a poor thermal efficiency, a slow response time and a slow start up from cold.

An alternative, potentially more responsive, process relies upon the partial oxidation of the hydrocarbon fuel. This can be represented by the following exothermic reaction:



The optimum oxygen to carbon ratio ($O_2:C$) depends on the processor conditions and increases as the carbon content of the hydrocarbon increases. Again a catalyst can be used to increase the reaction rate. To prevent clogging of the catalyst, most typically by coke deposition, the initial combustion can occur at high temperatures in the absence of a catalyst to break the hydrocarbon fuel down to simpler molecules. The gas stream is then passed over a catalyst to further break down the molecules into carbon monoxide and hydrogen. Although such a processor exhibits a faster response it has relatively lower hydrogen conversion efficiency than a steam reforming system.

It has been further proposed to provide fuel processors which use an "autothermal reforming process" to convert the hydrocarbon fuel to hydrogen and carbon monoxide with a combination of the above two processes. In such a processor the heat liberated by the exothermic partial oxidation reaction (Eq. 2) is used to drive the endothermic steam reforming reaction (Eq. 1) thereby improving the overall thermal efficiency of the processor. Different specialist catalysts may be used in physically separate partial oxidation and steam reforming reaction volumes within the processor or alternatively the partial oxidation and steam reforming reactions can take place over a common catalyst bed. The latter produces a simpler system design but places great demands on the catalyst material. In one known design the vaporised fuel is mixed with air and steam and then injected into an enclosure containing the granulated catalyst material.

At present the known fuel processors capable of processing heavier hydrocarbons fuels such as diesel are not ideally suited to small scale mobile applications. Firstly, the endothermic nature of the steam generating and steam reforming processes does not readily lend itself to operating efficiently on a small scale. Secondly, the comparatively high carbon content (high carbon to hydrogen ratio C:H) of many hydrocarbon fuels such as diesel clogs the catalyst through the deposition of coke (carbon) on the surface of the catalyst which blocks access to the active surface of the catalyst. Thirdly, the high sulphur level in many heavier hydrocarbon fuels poisons, that is reduces the activity of, the known catalysts used in the steam-reforming process thereby degrading the conversion efficiency.

The known catalysts for fuel conversion, or reforming, comprise base metals (such as nickel), noble metals (such as platinum), or a mixture of these, either in powdered form or as a coating on the surface of an inert ceramic substrate. The noble metal is generally dispersed in the form of small particles in order to minimise the metal cost and maximise the surface activity. These catalysts are, however, adversely affected by sulphur present in the fuels and are vulnerable to coking since there is no mechanism to remove the carbon from the catalyst surface once it has been deposited. There is therefore considerable scope for the development of improved catalyst systems that are cheaper, more efficient and more versatile than the current materials.

10 The present invention has arisen in an endeavour to develop a new catalyst formulation which is suitable for use with diesel and other heavy hydrocarbon fuels in an autothermal fuel processing system, and which is in part at least resistant to both sulphur poisoning and clogging with coke deposition.

15 According to the present invention there is provided use of a rare earth metal cobalt oxide ($MCoO_3$) having the perovskite crystal structure as a catalyst in a hydrocarbon fuel processor for converting or reforming a hydrocarbon fuel into a simple fuel most especially hydrogen. Due to its high oxygen ion mobility at temperatures at which such fuel processors operate, typically less than $800^\circ C$, use of such a catalyst offers a
20 number of advantages over the known catalysts: (i) the presence of the oxygen ions at the catalyst surface coating promotes the fuel breakdown process; (ii) the oxygen ions oxidise any carbon or contaminants which may be deposited on the catalyst surface coating during the fuel breakdown reaction and this reduces the likelihood of the catalyst becoming clogged, especially when using a high C:H fuel such as diesel, and

(iii) the oxygen ions prevent contaminants which might otherwise de-activate the catalyst, such as sulphur, becoming bonded to the surface coating. The inventors further believe that during the use of the catalyst the surface decomposes and becomes covered with a catalytically active coating of rare earth oxide, hydrated rare-earth oxide and cobalt metal particles which prevents the catalyst's activity becoming rapidly degraded by carbon deposition and/or by the effects of sulphur or other contaminants. A catalyst in accordance with the invention can therefore be said to be self cleaning. In contrast the known catalysts comprise an inert support structure with a catalytically active coating which is vulnerable to the effects of carbon and/or sulphur.

Advantageously the catalyst further includes a noble metal or noble metal oxide. Such a catalyst offers a high catalytic activity in which the oxygen ions provide a scouring activity which protects the activity of the noble metal or noble metal oxide at the operating temperature of the fuel processor. In one embodiment the noble metal or noble metal oxide comprises platinum or platinum oxide. In a particularly preferred embodiment the noble metal or noble metal oxide comprises ruthenium or ruthenium oxide which is found to give at least the same activity but which has a cost appreciably less than that of platinum. Preferably the noble metal or noble metal oxide is present up to 2 mole %.

Preferably the catalyst further comprises a solid solution having the perovskite crystal structure of the rare earth metal cobalt oxide and an alkaline earth metal cobalt oxide, such as for example a solid solution of lanthanum cobalt oxide and strontium cobalt

oxide. The substitution of the rare earth ions by alkaline earth ions increases the number of vacant sites for oxygen within the perovskite crystal structure thereby increasing the number and the mobility of oxygen ions within the crystal lattice. Advantageously the alkaline earth metal cobalt oxide is included in a proportion of up to 50%.

In a preferred catalyst composition the alkaline earth metal comprises strontium although calcium or barium can be used.

According to a second aspect of the invention a hydrocarbon fuel processor catalyst is characterised by comprising a rare earth metal cobalt oxide having the perovskite structure as described above. According to a third aspect of the invention a hydrocarbon fuel processor for converting a hydrocarbon fuel to hydrocarbon incorporates a catalyst as described above.

15

Nine catalyst compositions in accordance with the invention will now be described by way of example only. The first catalyst composition described is lanthanum cobalt oxide (LaCO_3) having the perovskite crystal structure. Lanthanum oxide (La_2O_3) powder was heated in air at 1000°C to decompose any Lanthanum Hydroxide $\text{La}(\text{OH})_3$ present in the material to give single phase La_2O_3 . The single phase La_2O_3 material was mixed with cobalt oxide (CoO) powder in appropriate weights to give the LaCoO_3 and the mixture ball-milled for 4 hours in approximately 40 gramme batches and then calcined (heated in a furnace) in air at 1050°C for 3 hours. The ceramic product after calcining was crushed and graded into a desired particle size,

approximately 1-10 μ m, prior to testing. As will be appreciated by those skilled in the art, the desired particle size will depend on the type of fuel processor and can accordingly be readily optimised for a required application.

5 X-ray diffraction studies of the material showed the crystal structure to be a substantially phase pure perovskite crystal structure. The perovskite crystal structure is that which exists in mineral perovskite CaTiO₃ and which is commonly adopted in compounds having the general formula ABO₃ where A is a relatively large cation (lanthanum in this example) and B is a relatively smaller cation (cobalt in this example). The B cations are each surrounded by a maximum of six oxygen ions to form a three-dimensional network of corner shared octohedra whilst the A cations occupy the interstices between the octohedra. The facile mixing of cations with different valences on both the A and B sites combined with the variable valence nature of the B cations promotes a complex defect structure which can provide a high mobility for the oxygen ions. X-ray diffraction patterns of samples showed that a significant quantity of La₂O₃ still remained in the samples which could not be eliminated by calcining for longer periods. This is believed to be a consequence of the CoO actually being a mixture of CoO and Co₃O₄, the latter of which cannot be readily converted to single CoO by heat treatment. To compensate for this a 5 mole
10 15 mobility for the oxygen ions. X-ray diffraction patterns of samples showed that a significant quantity of La₂O₃ still remained in the samples which could not be eliminated by calcining for longer periods. This is believed to be a consequence of the CoO actually being a mixture of CoO and Co₃O₄, the latter of which cannot be readily converted to single CoO by heat treatment. To compensate for this a 5 mole
20 % excess of CoO was added to the starting mixture. Samples prepared in this way showed only a trace of La₂O₃ remaining in the final composition.

Eight other catalyst compositions were synthesised which are shown in Table 1 below. First, samples were prepared containing the noble metals ruthenium (Ru) and

platinum (Pt) by calcining mixtures of La₂O₃, and PtO₂ or RuO₂ with a 5 mole % excess of CoO (compositions 2 and 3 in the table). Scanning electron microscopy analysis of the platinum oxide and ruthenium oxide powders showed that it was an extremely fine powder with a primary particle size probably well below 0.1µm
5 (dimensions beyond the resolution of the scanning electron microscope equipment available at the time of analysis). The energy-dispersive X-ray analysis in a scanning electron microscope of single grains of the resultant catalyst material confirmed that the platinum/ruthenium was present either within the grains or as a coating on the surface of the grains. No particles could be identified which were very rich in
10 platinum/ruthenium, suggesting that the noble metal is not present as a second phase (either as the metal or as the oxide).

Catalysts containing the noble metal and/or noble metal oxide were found to exhibit an enhanced activity compared to LaCoO₃. This is attributed to the catalytic activity
15 of the noble metal which is protected against clogging and or contamination by the scouring effect of the high mobility oxygen ions from the LaCoO₃ perovskite crystal structure. This being said it will be appreciated that the concentration of noble metal is selected such that there is sufficient LaCoO₃ to provide adequate cleaning of the metal. Test results indicate that ruthenium is at least as effective as platinum but has
20 the substantial advantage of being much lower in cost.

Composition 1	Composition 4	Composition 7
LaCoO_3	$\text{La}_{0.75}\text{Sr}_{0.25}\text{CoO}_3$	$\text{La}_{0.5}\text{Sr}_{0.5}\text{CoO}_3$
Composition 2	Composition 5	Composition 8
LaCoO_3 + 2 mole % PtO_2	$\text{La}_{0.75}\text{Sr}_{0.25}\text{CoO}_3$ + 2 mole % PtO_2	$\text{La}_{0.5}\text{Sr}_{0.5}\text{CoO}_3$ + 2 mole % PtO_2
Composition 3	Composition 6	Composition 9
LaCoO_3 + 2 mole % RuO_2	$\text{La}_{0.75}\text{Sr}_{0.25}\text{CoO}_3$ + 2 mole % RuO_2	$\text{La}_{0.5}\text{Sr}_{0.5}\text{CoO}_3$ + 2 mole % RuO_2

Table 1: Catalyst compositions.

In the remaining compositions (4 to 9), a fraction of the lanthanum ions was replaced by strontium (Sr) ions to form a solid solution of LaCoO_3 and SrCoO_3 . A 5 mole % excess of CoO was also added to the starting mixtures of these compositions. The calcination temperature needed for the complete elimination of La_2O_3 decreased as the strontium content increased, and was found to be 950°C for $\text{La}_{0.5}\text{Sr}_{0.5}\text{CoO}_3$. The complete list of synthesized samples is given in Table 1. The substitution of the lanthanum ions by strontium ions increases the number of vacant sites for oxygen within the perovskite structure thereby increasing the number and the mobility of oxygen ions within the crystal lattice.

Testing of the catalysts with diesel and other hydrocarbon fuels in a fuel processor showed the material to have good catalytic activity which was resistant both to clogging by coke or other contaminants and to poisoning from sulphur. The following results pertain to Composition 3 in the above Table 1. This composition 5 was tested with a range of liquid hydrocarbon fuels including liquid petroleum gas (LPG – a mixture of propane and butane), paraffin, gasoline and diesel.

As far as possible, the same test procedure was used for each of these fuels. The steam to carbon ratio ($H_2:C$) and air to carbon ratio ($O_2:C$) ratios were fixed during 10 initial temperature-programmed tests. The feed temperature was then ramped up from approximately 350°C to 850°C and then back down to 350°C, while the hydrogen (H_2), carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4) and heavier hydrocarbon content of the dried output gas stream were measured. The aim was to determine whether coke deposition or deactivation with sulphur occurred over a 15 portion of the temperature ramp. For example, coke deposition often occurred at low temperatures but was normally burnt off by the catalyst at higher temperatures. The plot of the hydrogen content versus temperature then showed a hysteretic effect where, at a selected feed temperature, the hydrogen content was lower when the catalyst temperature was raised than when the catalyst temperature was lowered.

20

Following the temperature ramp, the temperature of the fuel, air and steam feed was held constant at selected values, typically 600°C or 800°C. The composition of the feed, that is steam to carbon ratio ($H_2O:C$) and air to carbon ratio ($O_2:C$), more especially the ratio of the oxygen content of the air to carbon, were then altered and

the measurements repeated to determine the conditions providing the best catalytic activity. The steam and air to carbon ratios used are shown in Table 2. These conditions were chosen because they resulted in the near autothermal conversion of the heavier liquid fuels (paraffin, gasoline and diesel).

5

H ₂ O:C	O ₂ :C
1.0	0.38
1.5	0.50
2.0	0.64

Table 2: Steam (H₂O:C) and air (O₂:C) to carbon ratios used for the catalyst tests.

The results obtained are summarised in Table 3. These data were obtained while the
10 feed temperature was held at a constant value, and shows the hydrogen (H₂), carbon monoxide (CO) and methane (CH₄) content of the output gas stream under the conditions that generated the highest hydrogen content for each tested fuel. As is discussed below the remainder of the output gas stream comprises nitrogen and carbon dioxide the former resulting from the use of air rather than oxygen in the
15 reaction process. In general, this occurred under near autothermal conditions using a H₂O:C ratio of 1.0 and a O₂:C ratio of 0.38. However, the use of LPG under these conditions gave very high reactor temperatures in excess of ~1000°C. The use of a higher H₂O:C ratio and a lower O₂:C ratio is therefore beneficial with this fuel since

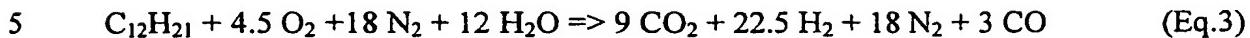
this maintained the catalyst bed at a lower temperature and also increased the concentration of hydrogen in the output gas stream

Fuel	Test Results				Test Conditions		
	% content of output gas stream			Catalyst temp. (°C)	O ₂ :C	H ₂ O:C	Feed temp. (°C)
	H ₂ max.	CO	CH ₄				
LPG	32.9	11.8	1.2	1007	0.38	2.0	600
	28.1	12.9	2.0	980	0.38	2.0	800
Paraffin	40.5	10.1	0.5	587	0.38	1.0	600
	35.2	15.2	2.6	758	0.38	1.0	800
Unleaded gasoline	13.5	7.6	0.9	743	0.50	1.0	600
	21.6	13.2	3.7	781	0.38	1.0	800
City diesel	34.9	9.5	0.6	594	0.38	1.0	600
	32.5	13.9	2.4	755	0.38	1.0	800

5 Table 3: Test results and test conditions for various hydrocarbon fuels using the catalyst composition 3.

10 The small concentrations of fuel or other hydrocarbons exiting the reactor (less than 5%) indicate that near complete conversion was obtained for LPG, paraffin and diesel. For all of these fuels, the maximum hydrogen content under these conditions is calculated to fall within the range 42%-48%. Taking diesel as an example, the

average molecular weight of this fuel is assumed to be ~170 and the chemical composition approximates to $C_{12}H_{21}$. For $H_2O:C = 1$ and $O_2:C = 0.38$, the reaction stoichiometry for complete conversion would then be:



The composition of the reformatory would therefore be:



10

so that the maximum hydrogen content extractable from this fuel under these conditions is ~43%.

The conversion efficiency for gasoline was lower than that of the other tested fuels,
and this is attributed to the higher sulphur content of this fuel. The LPG, paraffin and
city diesel had a very low sulphur contents (less than 10ppm) while the unleaded
gasoline had a much higher sulphur content of 100ppm. However, the temperature
programmed data obtained with gasoline indicate that retained sulphur species on the
catalyst surface desorbed at high temperatures around 800°C so that operation under
these conditions at least partially restored the catalytic activity.

The inventors believe that the good catalytic properties of these materials are due to their high oxygen ion mobility at temperatures for use in such fuel processors, typically less than 800°C. Firstly the presence of the oxygen ions at the catalyst

surface promotes the fuel breakdown process. Secondly the oxygen ions oxidise any carbon or contaminants which may be deposited on the catalyst surface during the fuel breakdown reactions thereby reducing the likelihood of catalyst clogging, especially when using a fuel having high carbon to hydrogen ratio such as diesel.

5 Thirdly the oxygen ions prevent contaminants, such as sulphur, becoming bonded to the surface which might otherwise de-activate the catalyst. It is believed that during the use of the catalyst a certain degree of decomposition of the Perovskite crystal structure occurs at the material surface such that the surface of the material becomes covered with a catalytically active coating of lanthium oxide (La_2O_3) and cobalt metal particles which prevents the catalyst's activity becoming rapidly degraded by carbon 10 deposition and/or by the effect of sulphur or other contaminants.

It will be appreciated that the present invention is not limited to the specific compositions described and that further compositions are envisaged which are within 15 the scope of the invention. For example the basic catalyst has been described in relation to LaCoO_3 though other rare earth metal (M) cobalt oxides (MCoO_3) having the perovskite crystal structure could be used. Furthermore it is envisaged to add other noble metals or noble metal oxides or a mixture thereof. Further it will be appreciated that solid solutions with alkaline earth metals other than strontium such 20 as calcium or barium can be used to increase the oxygen ion mobility. Furthermore it will be appreciated that a catalyst in accordance with the invention can be used for other types of hydrocarbon fuels other than diesel and is especially suited to use with heavier hydrocarbon fuels.

CLAIMS

1. Use of a rare earth metal cobalt oxide having the perovskite crystal structure as a catalyst in a hydrocarbon fuel processor for converting or reforming a hydrocarbon fuel into a simple fuel most especially hydrogen.
2. Use according to Claim 1 in which the catalyst further includes a noble metal or noble metal oxide.
3. Use according to Claim 1 or Claim 2 in which the catalyst comprises a solid solution having the perovskite crystal structure of the rare earth metal cobalt oxide and an alkaline earth metal cobalt oxide.
4. Use according to any preceding claim in which the rare earth metal is lanthanum.
5. Use according to any one of Claims 2 to 4 in which the noble metal or noble metal oxide is ruthenium or ruthenium oxide.
6. Use according to any one of Claims 2 to 4 in which the noble metal or noble metal oxide is platinum or platinum oxide.
7. Use according to Claim 3 or to any one of Claims 4 to 6 when dependent on Claim 3 wherein the alkaline earth is calcium, strontium or barium.

8. Use according to Claim 3 or any one of Claims 4 to 7 when dependent on Claim 3 in which the catalyst further includes the alkaline earth metal cobalt oxide in a proportion up to 50%.
9. Use according to Claim 2 or any one of Claims 3 to 8 when dependent on Claim 2 in which the noble metal or noble metal oxide is included up to 2 mole %.
10. Use according to any preceding claim in which the catalyst undergoes thermal decomposition such that its surface becomes coated with catalytically active lanthium oxide, hydrated lanthium oxide and cobalt metal particles.
11. A hydrocarbon fuel processor catalyst characterised by comprising a rare earth metal cobalt oxide having the perovskite crystal structure.
12. A catalyst according to Claim 11 and further including a noble metal or noble metal oxide.
13. A catalyst according to Claim 11 or Claim 12, which comprises a solid solution having the perovskite crystal structure of the rare earth metal cobalt oxide and an alkaline earth metal cobalt oxide.
14. A catalyst according to any one of Claims 11 to 13 in which the rare earth metal is lanthanum.

15. A catalyst according to any one of Claims 12 to 14 in which the noble metal or noble metal oxide is ruthenium or ruthenium oxide.
16. A catalyst according to any one of Claims 12 to 14 in which the noble metal or noble metal oxide is platinum or platinum oxide.
17. A catalyst according to Claim 13 or to any one of Claims 14 to 16 when dependent on Claim 13 in which the alkaline earth is calcium, strontium or barium.
18. A catalyst according to Claim 13 or any one of Claims 14 to 17 when dependent on Claim 13 and including the alkaline earth metal cobalt oxide in a proportion up to 50%.
19. A catalyst according to Claim 12 or any one of Claims 13 to 18 when dependent on Claim 12 and comprising including, the noble metal or noble metal oxide up to 2 mole %.
20. A hydrocarbon fuel processor for converting a hydrocarbon fuel to hydrogen incorporating a catalyst according to any one on Claims 11 to 19.

INTERNATIONAL SEARCH REPORT

Int'l Application No

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C01B3/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 638 (C-1133), 26 November 1993 (1993-11-26) & JP 05 200292 A (MITSUI ENG & SHIPBUILD CO LTD), 10 August 1993 (1993-08-10) abstract ---	1
A	US 5 149 516 A (HAN SCOTT ET AL) 22 September 1992 (1992-09-22) claim 1; example 1 ---	1
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 12, 26 December 1996 (1996-12-26) & JP 08 196907 A (IDEMITSU KOSAN CO LTD), 6 August 1996 (1996-08-06) abstract ---	1
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 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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Int'l Serial Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5 752 995 A (KANG CHIA-CHEN CHU) 19 May 1998 (1998-05-19) claim 1 -----	1
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JP 08196907	A	06-08-1996	NONE		
US 3993459	A	23-11-1976	DE CA FR GB JP	2421051 A 1057733 A 2269374 A 1467084 A 50149594 A	06-11-1975 03-07-1979 28-11-1975 16-03-1977 29-11-1975
US 5752995	A	19-05-1998	CA WO	2170408 A 9600613 A	11-01-1996 11-01-1996
US 4321250	A	23-03-1982	NONE		
US 5447705	A	05-09-1995	FR NO	2696109 A 933420 A	01-04-1994 29-03-1994

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

Tox

**Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE**

in its capacity as elected Office

Date of mailing (day/month/year) 11 April 2001 (11.04.01)	ETATS-UNIS D'AMERIQUE in its capacity as elected Office
International application No. PCT/GB00/02893	Applicant's or agent's file reference P/61802/PC
International filing date (day/month/year) 27 July 2000 (27.07.00)	Priority date (day/month/year) 28 July 1999 (28.07.99)
Applicant	
HARRISON Martin Roy et al	

- 1. The designated Office is hereby notified of its election made:**

in the demand filed with the International Preliminary Examining Authority on:

05 February 2001 (05:02:01)

in a notice effecting later election filed with the International Bureau on:

2. The election was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

<p>The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland</p> <p>Facsimile No.: (41-22) 740.14.35</p>	<p>Authorized officer Juan Cruz</p> <p>Telephone No.: (41-22) 338.83.38</p>
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PCT/GB00/0200
PENT COOPERATION TREA

PC

3 NOV 2000

PCT

NOTIFICATION CONCERNING
SUBMISSION OR TRANSMITTAL
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

Date of mailing (day/month/year) 19 October 2000 (19.10.00)		From the INTERNATIONAL BUREAU To: HOSTE, Colin, Francis Marconi Intellectual Property Waterhouse Lane Chelmsford Essex CM1 2QX ROYAUME-UNI	
Applicant's or agent's file reference P/61802/PC - <i>File WOP CWP PLS</i>		IMPORTANT NOTIFICATION	
International application No. PCT/GB00/02893		International filing date (day/month/year) 27 July 2000 (27.07.00)	
International publication date (day/month/year) Not yet published		Priority date (day/month/year) 28 July 1999 (28.07.99)	
Applicant MARCONI CASWELL LIMITED et al			
<p>1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).</p> <p>2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.</p> <p>3. An asterisk(*) appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.</p> <p>4. The letters "NR" appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.</p>			
<u>Priority date</u> 28 July 1999 (28.07.99)	<u>Priority application No.</u> 9917583.8	<u>Country or regional Office or PCT receiving Office</u> GB	<u>Date of receipt of priority document</u> 01 Sept 2000 (01.09.00)

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. (41-22) 740.14.35	Authorized officer R. Raissi Telephone No. (41-22) 338.83.38
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PATENT COOPERATION TREATY

WO 01/07359
PCT/GB00/02893

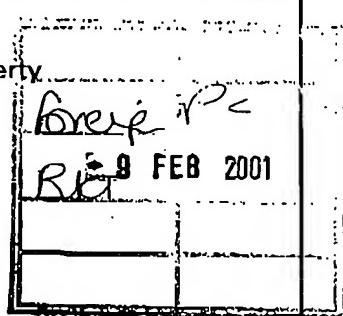
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PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

Date of mailing (day/month/year) 01 February 2001 (01.02.01)	From the INTERNATIONAL BUREAU	
Applicant's or agent's file reference P/61802/PC	To: HOSTE, Colin, Francis Marconi Intellectual Property Waterhouse Lane Chelmsford Essex CM1 2QX ROYAUME-UNI	
International application No. PCT/GB00/02893	International filing date (day/month/year) 27 July 2000 (27.07.00)	Priority date (day/month/year) 28 July 1999 (28.07.99)
Applicant MARCONI CASWELL LIMITED et al	IMPORTANT NOTICE	



1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
AU,KP,KR,US

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:

AE,AG,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,BZ,CA,CH,CN,CR,CU,CZ,DE,DK,DM,DZ,EA,EE,EP,ES,
FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,

MN,MW,MX,MZ,NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,
The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
01 February 2001 (01.02.01) under No. WO 01/07359

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 18 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/I/B/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

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**INFORMATION CONCERNING ELECTED
OFFICES NOTIFIED OF THEIR ELECTION**

(PCT Rule 61.3)

From the INTERNATIONAL BUREAU

To:

TOLFREE, Roger Keith
 Marconi Intellectual Property
 Waterhouse Lane
 Chelmsford
 Essex CM1 2QX
 ROYAUME-UNI

Date of mailing (day/month/year) 11 April 2001 (11.04.01)		
Applicant's or agent's file reference P/61802/PC	IMPORTANT INFORMATION	
International application No. PCT/GB00/02893	International filing date (day/month/year) 27 July 2000 (27.07.00)	Priority date (day/month/year) 28 July 1999 (28.07.99)
Applicant MARCONI CASWELL LIMITED et al		

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

AP :GH,GM,KE,LS,MW,MZ,SD,SL,SZ,TZ,UG,ZW
 EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
 National :AU,BG,CA,CN,CZ,DE,IL,JP,KP,KR,MN,NO,NZ,PL,RO,RU,SE,SK,US

2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
 OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
 National :AE,AG,AL,AM,AT,AZ,BA,BB,BR,BY,BZ,CH,CR,CU,DK,DM,DZ,EE,ES,FI,GB,
 GD,GE,GH,GM,HR,HU,ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MW,
 MX,MZ,PT,SD,SG,SI,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW

3. The applicant is reminded that he must enter the "national phase" before the expiration of 30 months from the priority date before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing, if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

The entry into the European regional phase is postponed until 31 months from the priority date for all States designated for the purposes of obtaining a European patent.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. (41-22) 740.14.35	Authorized officer: Juan Cruz Telephone No. (41-22) 338.83.38
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PATENT COOPERATION TREATY

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From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

WRITTEN OPINION

(PCT Rule 66)

To: TOLFREE, Roger Keith Marconi Intellectual Property Waterhouse Lane CHELMSFORD ESSEX CM1 2BT GRANDE BRETAGNE GC

Date of mailing (day/month/year) 12/06/01	
Applicant's or agent's file reference P/61802/PC	REPLY DUE within 1 months/days from the above date of mailing
International application No. PCT/GB 00/02893	International filing date (day/month/year) 27/07/2000
Priority date (day/month/year) 28/07/1999	
International Patent Classification (IPC) or both national classification and IPC C01B3/40	
Applicant MARCONI CASWELL LIMITED et al.	

1. This written opinion is the _____ (first, etc.) drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

- I Basis of the opinion
- II Priority
- III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV Lack of unity of invention
- V Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI Certain documents cited
- VII Certain defects in the international application
- VIII Certain observations on the international application

3. The applicant is hereby invited to reply to this opinion.

When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3.
For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also For an additional opportunity to submit amendments, see Rule 66.4.
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4bis.
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 28/11/2001

Name and mailing address of the IPEA/ European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 epmu d Fax: (+49-89) 2399-4465	Authorized officer Examining Officer: Bernard Louis Petit Formalities officer (incl. extension of time limits)
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INTERNATIONAL PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

KM KAU
FOREIGN PC
PCT - 2 JAN

EGB

NOTIFICATION OF TRANSMITTAL OF
INTERNATIONAL PRELIMINARY
EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing
(day/month/year)**18.12.01**

Applicant's or agent's file reference P/61802/PC		IMPORTANT NOTIFICATION	
International application No. PCT/ GB 00/ 02893	International filing date (day/month/year) 27/07/2000	Priority date (day/month/year) 28/07/1999	
Applicant MARCONI CASWELL LIMITED et al.			

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.
4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/  European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 epmu d Fax: (+49-89) 2399-4465	Authorized officer P. Koutsoftas
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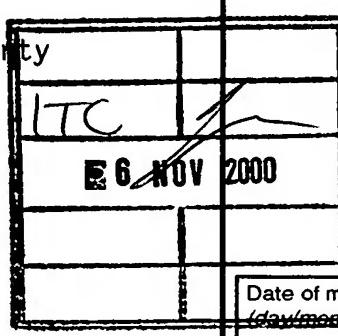


PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:

Marconi Intellectual Property
 Attn. HOSTE, Colin Francis
 Waterhouse Lane
 CHELMSFORD ESSEX CM1 2QX
 UNITED KINGDOM

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL SEARCH REPORT
OR THE DECLARATION

(PCT Rule 44.1)

BEST AVAILABLE COPY

07/11/2000

Applicant's or agent's file reference
P/61802/PC

FOR FURTHER ACTION See paragraphs 1 and 4 below

International application No.
PCT/GB 00/ 02893International filing date
(day/month/year) 27/07/2000

Applicant

MARCONI CASWELL LIMITED

1. The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
 34, chemin des Colombettes
 1211 Geneva 20, Switzerland
 Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within 19 months from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within 20 months from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority
 European Patent Office, P.B. 5818 Patentlaan 2
 NL-2280 HV Rijswijk
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
 Fax: (+31-70) 340-3016

Authorized officer

Chantal Meyer

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the International application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been /is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the International application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the International application is English, the letter must be in English; if the language of the International application is French, the letter must be in French.

NOTES TO FORM PCT/ISA/220 (continued)

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

- (i) the claim is unchanged;
- (ii) the claim is cancelled;
- (iii) the claim is new;
- (iv) the claim replaces one or more claims as filed;
- (v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the International application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREATY

PCT

BEST AVAILABLE COPY

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference P/61802/PC	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 00/02893	International filing date (day/month/year) 27/07/2000	(Earliest) Priority Date (day/month/year) 28/07/1999
Applicant MARCONI CASWELL LIMITED		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the language, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
 - the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
- b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of the sequence listing :
 - contained in the international application in written form.
 - filed together with the international application in computer readable form.
 - furnished subsequently to this Authority in written form.
 - furnished subsequently to this Authority in computer readable form.
 - the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
 - the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished
- 2. Certain claims were found unsearchable (See Box I).
- 3. Unity of Invention is lacking (see Box II).
- 4. With regard to the title,
 - the text is approved as submitted by the applicant.
 - the text has been established by this Authority to read as follows:

5. With regard to the abstract,

- the text is approved as submitted by the applicant.
- the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is Figure No.

- as suggested by the applicant.
- because the applicant failed to suggest a figure.
- because this figure better characterizes the invention.

None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/02893

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C01B3/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 638 (C-1133), 26 November 1993 (1993-11-26) & JP 05 200292 A (MITSUI ENG & SHIPBUILD CO LTD), 10 August 1993 (1993-08-10) abstract ---	1
A	US 5 149 516 A (HAN SCOTT ET AL) 22 September 1992 (1992-09-22) claim 1; example 1 ---	1
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 12, 26 December 1996 (1996-12-26) & JP 08 196907 A (IDEMITSU KOSAN CO LTD), 6 August 1996 (1996-08-06) abstract ---	1
	-/-	

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

° Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

25 October 2000

07/11/2000

Name and mailing address of the ISA

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Authorized officer

Clement, J-P

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/02893

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 993 459 A (KOCH CHRISTIAN ET AL) 23 November 1976 (1976-11-23) claim 1 ---	1
A	US 5 752 995 A (KANG CHIA-CHEN CHU) 19 May 1998 (1998-05-19) claim 1 ---	1
A	US 4 321 250 A (HART PETER J) 23 March 1982 (1982-03-23) claim 1 ---	1
A	US 5 447 705 A (PETIT CORINNE ET AL) 5 September 1995 (1995-09-05) claim 1 -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/02893

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
JP 05200292	A	10-08-1993	NONE		
US 5149516	A	22-09-1992	NONE		
JP 08196907	A	06-08-1996	NONE		
US 3993459	A	23-11-1976	DE	2421051 A	06-11-1975
			CA	1057733 A	03-07-1979
			FR	2269374 A	28-11-1975
			GB	1467084 A	16-03-1977
			JP	50149594 A	29-11-1975
US 5752995	A	19-05-1998	CA	2170408 A	11-01-1996
			WO	9600613 A	11-01-1996
US 4321250	A	23-03-1982	NONE		
US 5447705	A	05-09-1995	FR	2696109 A	01-04-1994
			NO	933420 A	29-03-1994

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PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

12

Applicant's or agent's file reference P/61802/PC	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/GB 00/02893	International filing date (day/month/year) 27/07/2000	Priority date (day/month/year) 28/07/1999
International Patent Classification (IPC) or national classification and IPC C01B3/40		
Applicant MARCONI CASWELL LIMITED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consists of a total of _____ sheets.

3. This report contains indications relating to the following items:

I Basis of the report
II Priority
III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV Lack of unity of invention
V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI Certain documents cited
VII Certain defects in the international application
VIII Certain observations on the international application

Date of submission of the demand 05/02/2001	Date of completion of this report 18.12.01
Name and mailing address of the IPEA/ European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 epmu d Fax: (+49-89) 2399-4465	Authorized officer Bernard Louis Pettit 

INTERNATIONAL PRELIMINARY EXAMINATION REPORT**I. Basis of the report**

1. This report has been drawn up on the basis of (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*)

the international application as originally filed

the description, pages , as originally filed

pages , filed with the demand

pages , filed with the letter of

the claims, Nos. , as originally filed

Nos. , as amended under Article 19

Nos. , filed with the demand

Nos. , filed with the letter of

the drawings, sheets / fig. , as originally filed

sheets / fig. , filed with the demand

sheets / fig. , filed with the letter of

2. The amendments have resulted in the cancellation of:

the description, pages:

the claims, Nos.

the drawings, sheets / fig.

3. This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2 (c)).

4. Additional observations, if necessary:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement****1. Statement**

Novelty	Claims	5, 6, 15, 16	YES
	Claims	1-4, 7-14, 17-20	NO
Inventive Step	Claims		YES
	Claims	5, 6, 15, 16	NO
Industrial Applicability	Claims	1-20	YES
	Claims		NO

2. Citations and Explanations

The cited document (1) US-A-4 321 250 confirms that it is conventional to provide and use oxides according to the definition of claim 11, and respectively claims 1 and 20.

The further features of claims 2-4, 7-10, 12, 13 and 17-19 are also known from this reference.

The idea of using noble metals as defined in claims 5, 6, 15 and 16 cannot be regarded as inventive, since said metals are conventionally used in the related art in combination with rare earth metals and cobalt in the same field of use.

Reference can be made for instance to cited Patent Abstracts of JP-A-08 196 907 and JP-A-05 200 292 or US-A-5 447 705.